The Technical Basis for Siting Additional Ambient Air Monitoring Stations for the Measurement of Tritiated Water Vapor at Lawrence Berkeley National Laboratory

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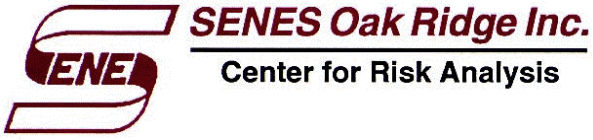

EXECUTIVE SUMMARY

This report describes the technical basis used to determine the placement of ambient air monitoring stations for the measurement of tritium at Lawrence Berkeley National Laboratory (LBNL).

The present ambient air monitoring network at LBNL includes 7 stations that use silica gel samplers to detect the presence of tritiated water vapor (HTO) in air. These stations meet all criteria mandated by the U.S. Department of Energy (DOE), which include coverage of the major wind sectors and siting at the nearest offsite location where a maximally exposed individual could receive an effective whole body dose exceeding 1 mrem/y. Releases of tritium from the National Tritium Labelling Facility (NTLF) at LBNL have been sufficiently low that exposures to individuals onsite and offsite have not exceeded (or even approached) 1 mrem/y. The applicable dose limit representing the National Emission Standard for Hazardous Air Pollutants (NESHAP) is 10 mrem/y.

Despite the fact that the present network satisfies all applicable requirements, an expansion of the network to 15 stations is presently proposed by LBNL. Two sites are proposed to address a supplemental monitoring request made by the Environmental Protection Agency (EPA) that will allow the agency to complete its evaluation of LBNL for possible listing as a Superfund site. Six sites have been proposed in response to recommendations made by an independent review of LBNL operations performed for the City of Berkeley (Franke and Greenhouse, 2000; 2001), and to concerns expressed by members of the Environmental Sampling Project Task Force. The locations for the additional 6 proposed monitoring stations were selected using the following siting criteria:

- the location of employees onsite and population centers offsite,
- the potential to represent each of the 16 standard wind sectors,
- the distance out to which HTO is measurable,
- the availability of dedicated electrical service,
- safe access to the monitoring station, and
- the ability to house and secure instruments.

Annual averaged air concentrations were estimated for annual releases of HTO of 30 Ci from the planned Building 75 rooftop stack at various distances and directions from the NTLF out to a radius of 5 km with the CALPUFF modeling system, which accounts for changes in local air movement due to the effects of complex terrain (Scire et al., 1999). A release of 30 Ci of HTO per year represents an emission rate anticipated from future normal operations of the NTLF based on an evaluation of releases for the past six years.

CALPUFF predictions of onsite air concentrations produce maximum concentration isolines of 10 to 20 pCi/m^3, diminishing to 10 to 0.1 pCi/m^3 offsite. Similar concentrations were produce with a wind tunnel study (White, 2001) and with the NESHAPs compliance code, CAP88-PC; however, the spatial pattern of tritium dispersion differed among all three methods. Differences between CALPUFF and the wind tunnel dispersion patterns are due to the inability of the wind tunnel to simulate hourly variations in atmospheric turbulence. Differences between CALPUFF and CAP88-PC are because CAP88-PC does not account for variations in wind direction and turbulence under complex terrain conditions that prevail at LBNL.

For an annual release of 30 Ci of HTO, the maximum onsite dose to a worker exposed during an average work year would be less than 0.032 mrem/y, regardless of which method is used to estimate downwind air concentrations of tritium. The maximum dose to an offsite resident exposed 24 hours per day would be less than 0.087 mrem/y. Effective whole body doses less than 1 mrem/y are considered negligible by the National Council on Radiation Protection and Measurements (NCRP).

This proposed network provides monitoring coverage in all standard wind directions within the limits of practicality of the complex LBNL site and, if implemented, will enhance the opportunity to validate and calibrate mathematical models that are used to estimate onsite and offsite air concentrations at locations not represented by an ambient air monitor.

ACKNOWLEDGMENTS

We would like to acknowledge Dr. Bruce White from the University of California at Davis who developed a scale model of the LBNL site for wind tunnel studies on the atmospheric dispersion of HTO released from the Building 75 rooftop stack and for sharing unpublished results, which are included in Section 3.2 of this report.

We also wish to acknowledge contributions from the following individuals at LBNL: Patrick Thorson for help in obtaining information on the criteria used by LBNL for siting existing monitoring stations, Henry Tran for providing us with estimated air concentrations using the CAP88-PC computer code, Michael Ruggieri for researching the background levels of tritium, and Ron Pauer for his review and comments on previous versions of this manuscript.

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1.0 INTRODUCTION

Lawrence Berkeley National Laboratory (LBNL) has operated an ambient air tritium monitoring network for nearly three decades. LBNL currently has a network of 7 ambient air monitoring stations for the measurement of airborne tritium released from the National Tritium Labelling Facility (NTLF) that use silica gel to trap tritiated water vapor (HTO).

The primary purpose of the existing network has always been to provide assurance to the Department of Energy that the environmental impacts from operations at the Laboratory satisfy both environmental regulations and DOE's internal set of orders.

In the case of tritium, the applicable environmental regulation is 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities" or NESHAPs for short. This NESHAPs regulation was first promulgated in 1989. Compliance with this regulation is based on an annual dose that is predicted by using EPA prescribed dispersion modeling of emissions. Ambient monitoring, although not required to establish NESHAPs compliance, is extremely useful in validating the predictions made with the model.

The primary reference that specifies the characteristics of the existing ambient air network is the DOE Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE, 1991). This reference guide specifies three factors that have traditionally determined the number and placement of sampling locations in the network: meteorology, demography, and the magnitude of projected doses to the surrounding population. Although the existing monitoring network meets all requirements in this DOE guide, LBNL is currently planning a significant expansion to its ambient air monitoring network. This expansion is in response to requests and concerns raised by members of the Environmental Sampling Project Task Force, recommendations made by the independent evaluation of LBNL operations for the City of Berkeley (Franke and Greenhouse, 2000; Franke and Greenhouse, 2001), and a request from EPA for two additional stations to supplement its ongoing Hazard Ranking System

scoring evaluation. The location for 6 of the 8 proposed sampling stations is based on the technical criteria described in Section 2.0, the dispersion modeling of annual averaged downwind air concentrations for a release of 30 Ci/y of HTO, and the considerations of the distances out to which average air concentrations of HTO are detectable. A discussion of the rationale for each monitoring location is given in Section 5.0 of this document.

2.0 SITING CRITERIA

The existing monitoring stations were sited based on the criteria given in DOE's Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE, 1991). The regulatory guide states that the exact number of samplers required at a particular site will be determined by the local meteorology, demography, and the magnitude of projected doses to the surrounding population. The DOE regulatory guide states that offsite air samplers should be placed at each DOE site having potential airborne releases that could result in an annual effective dose equivalent greater than 1 mrem per year to the maximally exposed individual. We note that at no time, either during present or past operations of the NTLF, have onsite or offsite air concentrations of HTO approached 1 mrem/y.

The placement of the additional ambient air monitors was based on criteria above and beyond the guidance provided by DOE. These criteria include the location of nearby population centers (both onsite and offsite), placement of monitors with respect to the 16 standard wind sectors, and whether the site would be able to detect tritium as HTO. Other criteria include the availability of dedicated electrical service and whether the site is easily and safely accessible and can support housing to secure instrumentation.

2.1 Location of Nearby Population Centers

A primary consideration in the placement of ambient air monitoring stations is the location of potentially exposed populations, both onsite and offsite. Priority for establishing the location of air monitoring stations is given to sites where individuals are likely to be exposed, including sites where people live, work, or visit.

2.2 Standard Wind Directions

The existing monitoring stations and the 16 standard wind sectors have been identified on an LBNL site map (Figure 1). Although observed wind patterns at the LBNL site indicate that the wind blows very rarely from some directions (e.g., the N, NNE, NE and ENE wind sectors), placement of the monitoring systems to represent the 16 standard wind sectors will assure that all releases from the NTLF, regardless of the direction that the wind is blowing during the time of release, will likely be monitored.

2.3 Expected Concentration to Occur at a Given Location

The analytical method used by the laboratory for processing samples from the ambient air monitors can detect concentrations of HTO as low as 2 to 5 pCi/m^3 for the given flow rate used by the LBNL sampling stations. It is desirable to place a monitor where it is likely to detect a tritium release. Estimation of annual averaged air concentrations downwind of the NTLF have been performed in the report using the CALPUFF modeling system that accounts for the changes in local patterns of air movement due to the effects of complex terrain (see Section 3.0).

2.4 Power, Accessibility, and Security

When siting ambient air monitors, several issues of practicality must be considered. The sampling equipment requires dedicated electric power. Once per month, an LBNL technician visits the monitoring station to collect the silica gel sample and send it to a laboratory for analysis; therefore, it is important that the monitoring site be safely accessible. Finally, it is imperative that the monitoring stations be placed in a location that will support housing and security to reduce opportunities for vandalism or tampering with equipment.

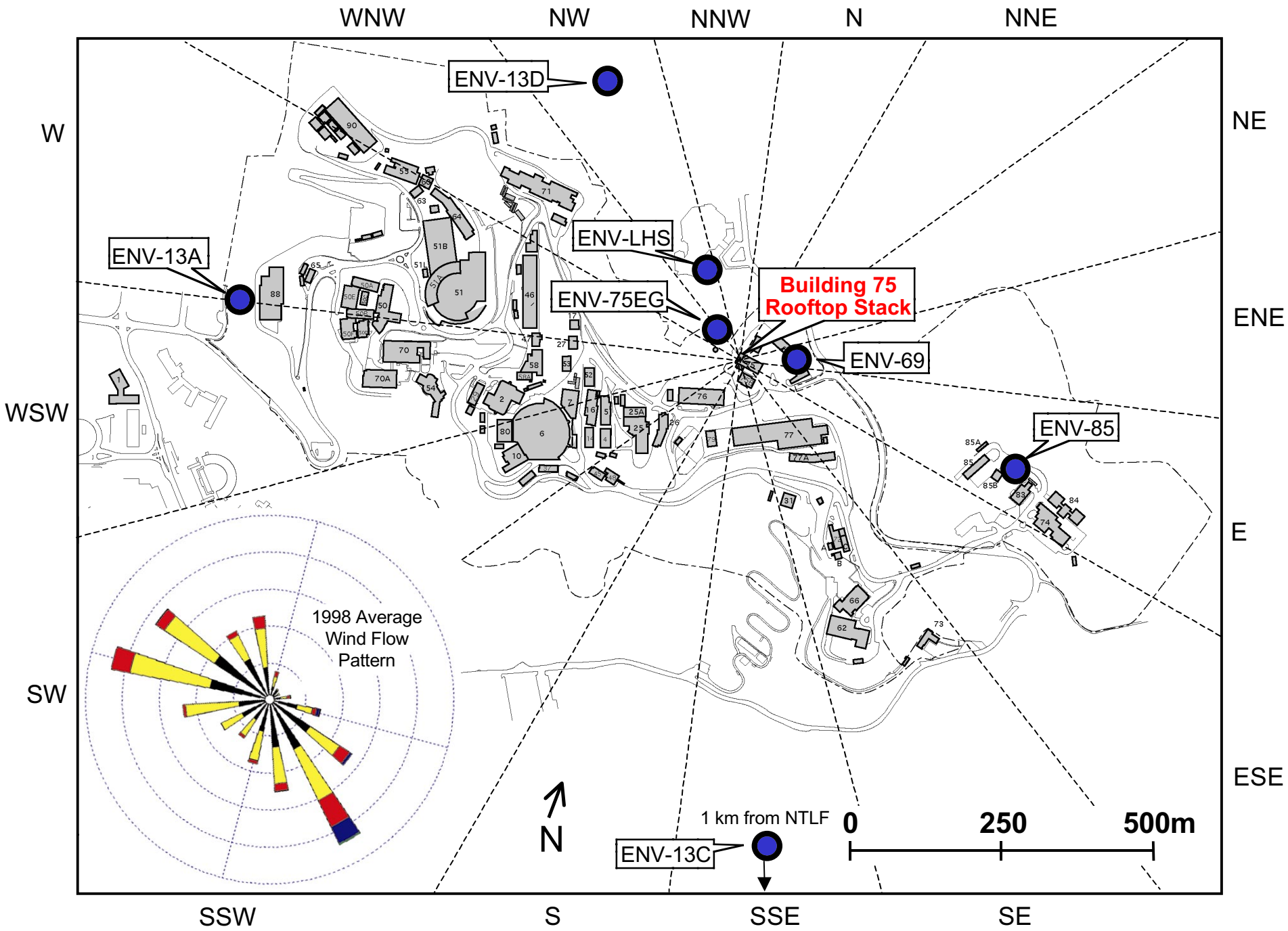

Figure 1. Sixteen standard wind sectors and existing monitoring locations.

3.0 ESTIMATED AIR CONCENTRATIONS OF HTO

Air concentrations have been estimated downwind from the NTLF using the CALPUFF modeling system (Scire et al., 1999) for the purposes of siting new monitoring stations. The results from CALPUFF have been compared to the results from the UC Davis Wind Tunnel studies and predictions made using the EPA regulatory model CAP88-PC (Parks, 1997).

The concentrations estimated in this report are based on the following conditions and assumptions:

- All releases occur from the planned Building 75 rooftop stack. This relocation is planned for this fiscal year ending 9/30/2001 and will replace the hillside stack.
  - The stack height above the ground is 9.1 meters (the building is 4.5 meters tall plus a 4.6 meter rooftop stack).
  - Stack diameter = 0.57 meters
  - Exit velocity = 11.9 m/s
  - Exit temperature = 20 C
- Meteorological data are from 1998 records at the onsite 20-meter tower.
- Emissions were assumed to be constant over the year for an annual release of 30 Ci.

  Although short-term deviations from the annual average will occur, annual averaged air concentrations are the most relevant indicators of the potential for long-term exposure to individuals on and offsite. The potential impacts of short-term exposures coinciding with short-term emissions have been addressed in a previous report (Thomas and Hoffman, 2000) and were found to be much less than the cumulative exposure that would occur over an extended period of time (one year or longer).

  An annual release of 30 Ci of HTO per year represents an emission rate anticipated from future normal operations of the NTLF, based on an evaluation of releases for the past six years. Table 1 below contains the annual average release amounts from 1995-2000.

Table 1. Annual tritium releases from the National Tritium Labelling Facility

Year	Total Tritium Released (Ci)
1995	53
1996	5
1997	41
1998	115[a]
1999	30
2000	25[b]

[a] Includes the July 1998 one-time accidental release of 35 Ci.
[b] Value not yet officially verified.

The values in Table 1 are totals for releases of HTO and HT combined. The estimates in this report conservatively assume that all releases are as HTO and may lead to an overestimate of HTO at distances near in to the NTLF rooftop stack. This assumption that all releases occur as HTO will also overestimate human exposures and doses as HTO is more readily taken up and retained by biological systems than is HT (NCRP, 1979).

3.1 CALPUFF Modeling System

The placement of additional monitors in the proposed network of ambient air monitors has been based on air concentrations estimated using the CALPUFF modeling system. CALPUFF is a non-steady-state air quality modeling system that consists of a meteorological modeling package (CALMET) with both diagnostic and prognostic wind field generators, a Gaussian puff dispersion model (CALPUFF) with chemical removal, wet and dry deposition, complex terrain algorithms, building downwash, plume fumigation, and other effects, and postprocessing programs (CALPOST) for the output fields of meteorological data, concentration and deposition fluxes (Scire et al., 1999). The applicability of the CALPUFF model to the LBNL site has been discussed in detail in a previous report (Thomas et al., 1999). CALPUFF has been applied and calibrated to the LBNL site in previous studies (Radonjic et al., 2000; Thomas and Hoffman, 2000; Thomas et al., 2000).

A summary of the reasons why CALPUFF was selected for this application include:

- Complex terrain transport of airborne materials is considered explicitly.
- The transport and dispersion of releases of HTO can be estimated from tens of meters to hundreds of kilometers.
- Estimates of air concentrations can be made for averaging times ranging from one hour to one year.

In addition, the Environmental Protection Agency (EPA) has proposed the CALPUFF modeling system as a *Guideline* model for use in regulatory applications for near-field conditions where non-steady-state effects (e.g., spatial variability in meteorological fields, calm winds, fumigation, recirculation or stagnation, and terrain or coastal effects) may be important.

Estimated downwind air concentrations for the modeled release were then plotted as contour lines on a base map of the region using SURFER computer software (Kekler, 1995). Surfer employs the Kriging interpolation technique among locations where specific concentrations are specified by CALPUFF. The input and output files for CALPUFF are provided in Appendix A.

Annual averaged air concentrations of HTO estimated out to a radius of approximately 1 km from the NTLF are presented in Figure 2. Estimates out to a radius of a 5 km are given in Figure 3 to show the location of stations ENV-13C and ENV-AR, and to show the full extent of concentration isolines down to levels as low as 0.1 pCi/m^3. Natural background levels of HTO are at 0.1 to 0.4 pCi/m^3 (IAEA, 1999; LLNL, 1998). The releases from the NTLF are incremental increases above this level.

The solid lines depict regions within which a silica gel sampler will likely be capable of detecting annual averaged concentrations of HTO in air. The dashed lines represent concentrations that are less than the limits of analytical detection for tritium. Based on CALPUFF estimates for a 30 Ci annual release, 9 monitoring stations (4 existing and 5 proposed) are sited in a location that will likely permit detection of a release of tritium from the NTLF.

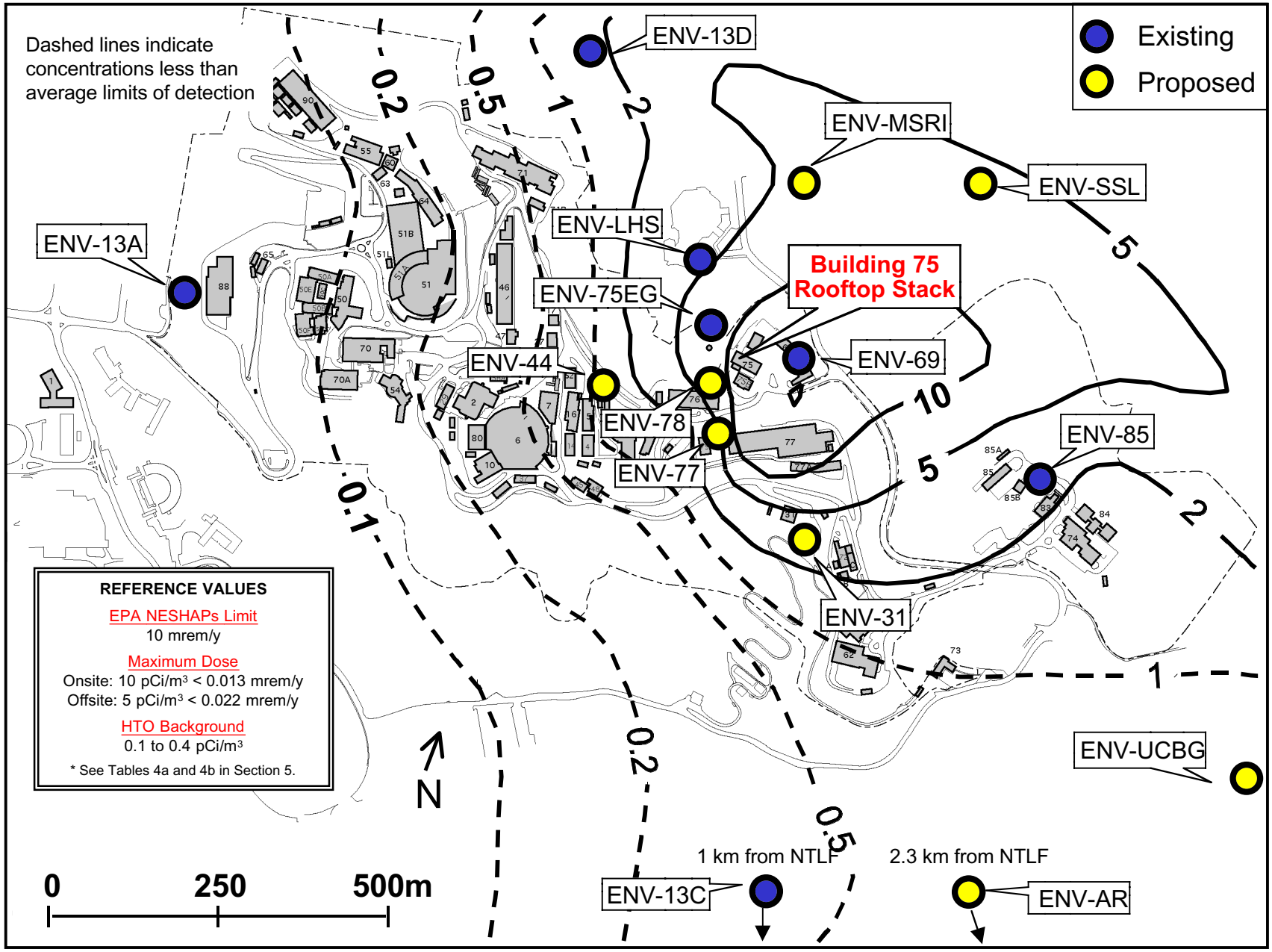

Figure 2. CALPUFF predictions of tritium air concentrations (pCi/m^3) for a 30 Ci annual release of HTO plotted on a site map of approximately 1 km radius.

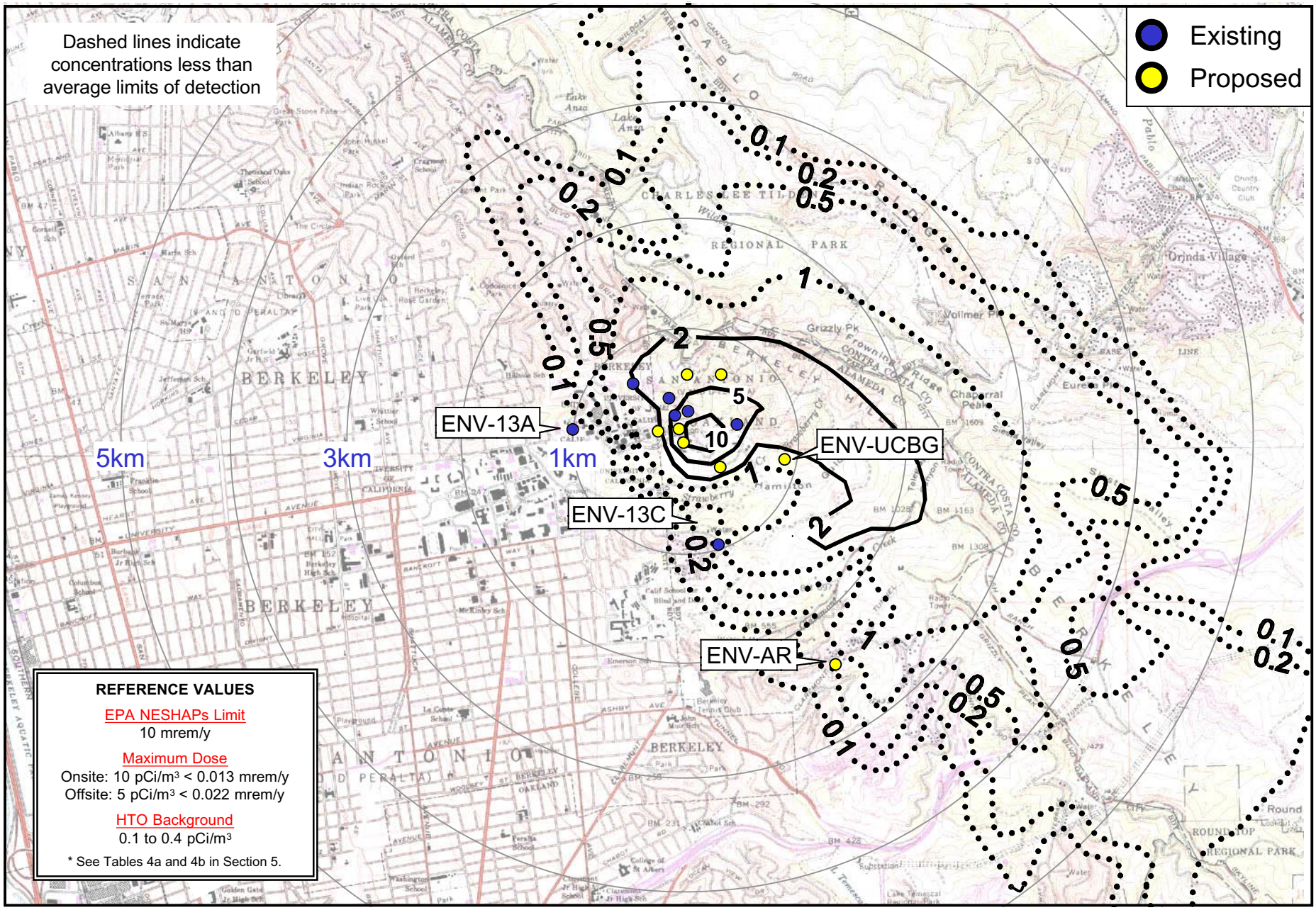

Figure 3. CALPUFF predictions of tritium air concentrations (pCi/m^3) for a 30 Ci annual release of HTO plotted on a site map of approximately 5 km radius.

3.2 Wind Tunnel Studies

The University of California at Davis has performed a wind tunnel study of the LBNL site. A scale model of the site, including buildings, topography, and ground cover, was created for this purpose (White, 2001). Wind tunnel data are provided in Appendix B.

Concentrations of HTO in air estimated by the wind tunnel study for an annual release of 30 Ci are presented in Figure 4. The isoconcentration lines generated from the wind tunnel data indicate less dispersion than was estimated using CALPUFF, especially in the NE direction. This difference is primarily due to the fact that the wind tunnel study can simulate changes in wind direction but cannot account for changes in atmospheric stability. The conditions in the wind tunnel are representative of atmospheric stability category B. On the other hand, CALPUFF incorporates hourly data that includes variations on atmospheric stability. Unlike dispersion models, the wind tunnel model is capable of taking into account site-specific surface roughness caused by the presence of buildings and vegetation.

While the patterns of dispersion predicted by the two approaches (CALPUFF and wind tunnel study) differ, the magnitude of the concentrations estimated by each approach are comparable.

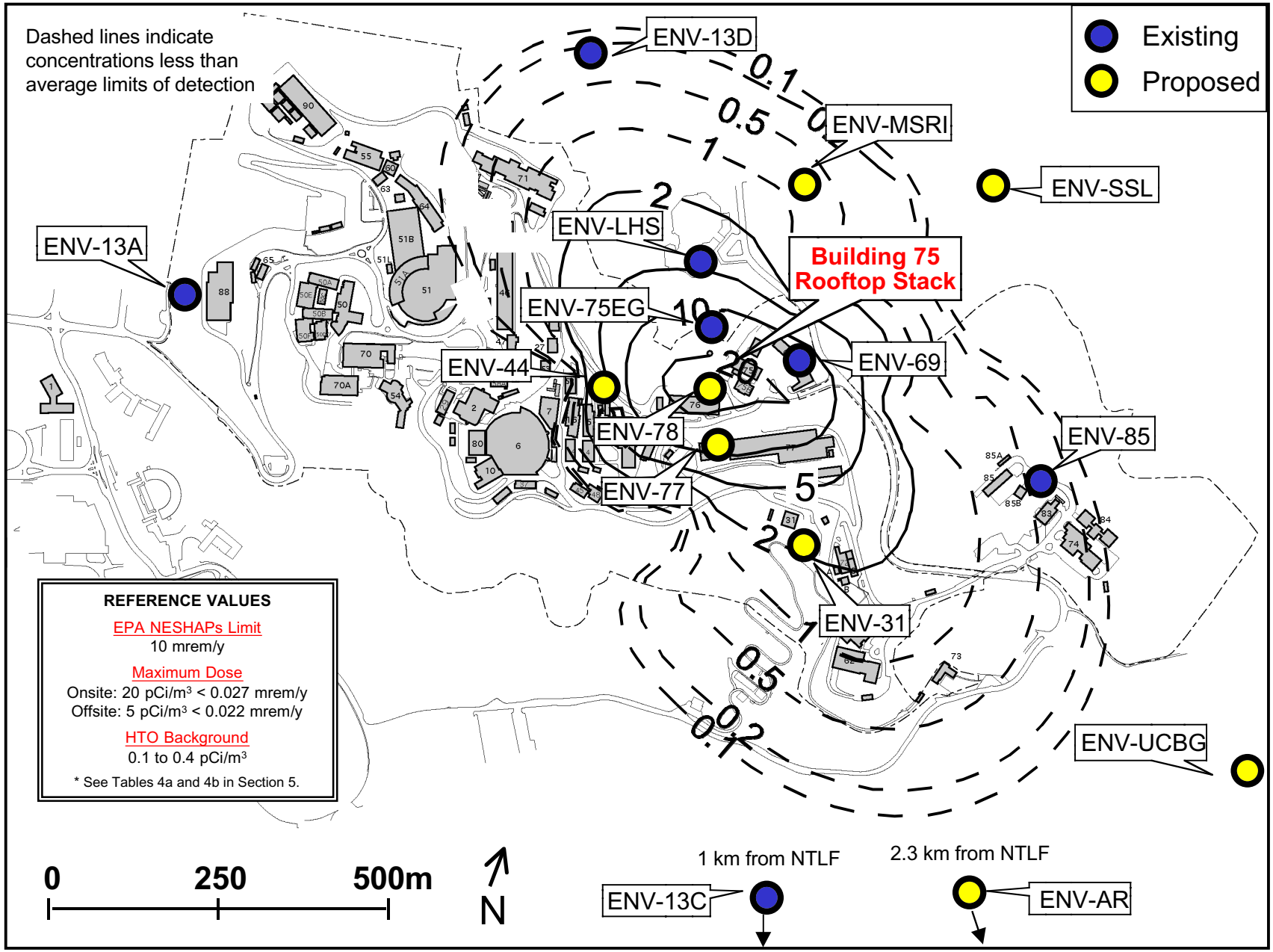

Figure 4. UC Davis wind tunnel predictions of tritium air concentrations (pCi/m^3) for a 30 Ci annual release of HTO plotted on a site map of approximately 1 km radius.

3.3 CAP88-PC Regulatory Model

Predictions from the EPA regulatory model CAP88-PC (Parks, 1997) have also been reviewed. The input and output files for CAP88-PC are provided in Appendix C. The concentrations depicted in Figure 5 are conservative due to simplifications made in the construction of the CAP88-PC computer code. For example, the CAP88-PC predictions are based on the assumption that the material was released over flat terrain.

The results from CAP88-PC have not been used for siting monitoring stations because downwind air concentrations produced with CAP88-PC are known to overestimate true concentrations (Thomas et al., 2000). For example, the results in Figure 5 suggests that at least 12 of the 15 monitoring stations discussed in this report would detect tritium released from the NTLF (only stations ENV 13A, ENV-SSL, and ENV-AR would be outside the range where tritium would likely be detected). By comparison, CALPUFF (Figure 3) indicates that 6 stations are outside the range of detection. The use of CAP-88 should be limited to the determination of whether NESHAP standards for the maximally exposed individual (MEI) are met or exceeded.

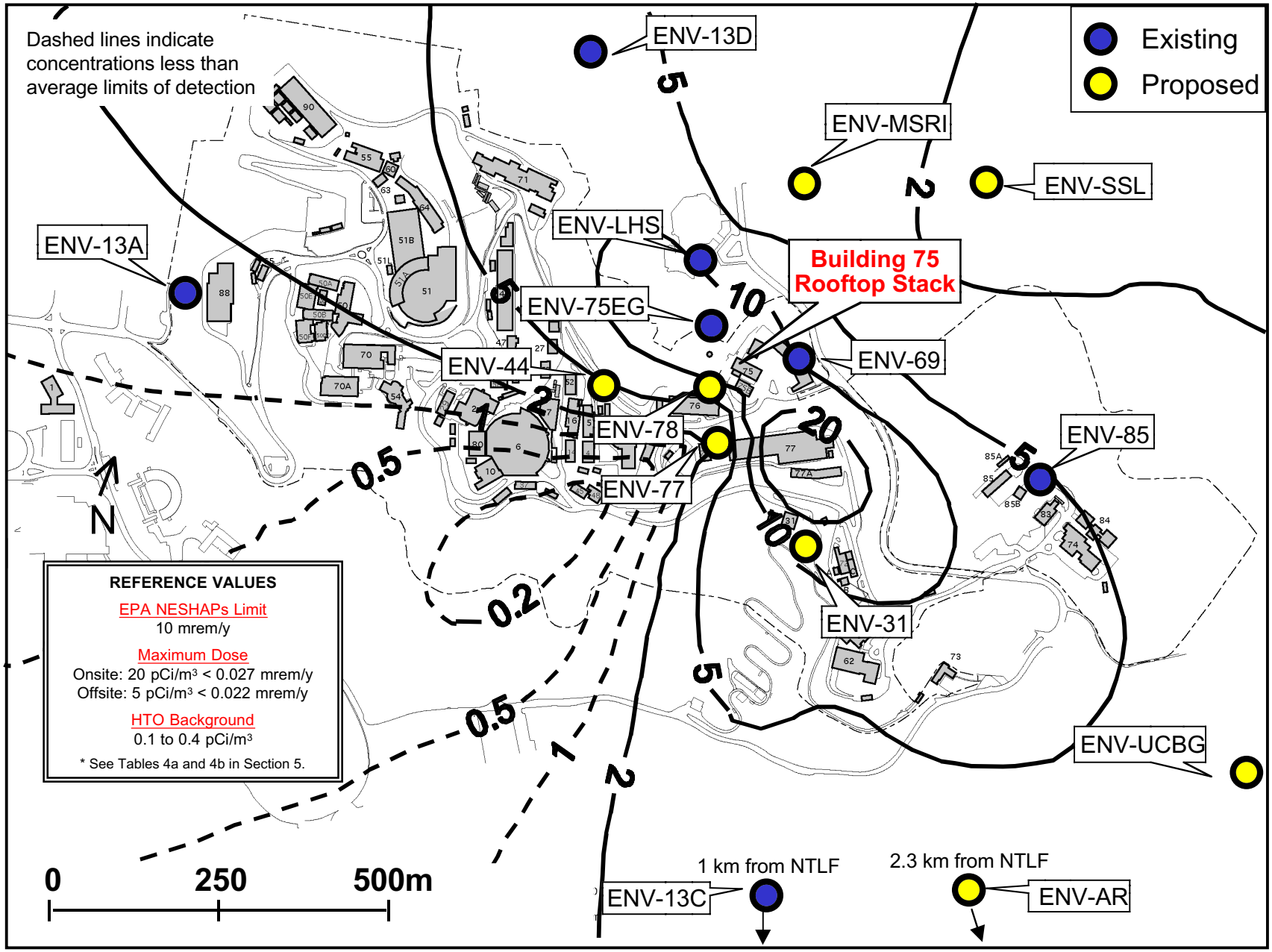

Figure 5. CAP88 predictions of tritium air concentrations (pCi/m^3) for a 30 Ci annual release of HTO plotted on a site map of approximately 1 km radius.

4.0 THE TECHNICAL BASIS FOR SITING EXISTING AND PROPOSED MONITORING STATIONS

The rationale for placement of existing and proposed ambient air monitoring stations is discussed below. The location of each monitoring station is identified in Figures 2 through 6. A checklist is provided of siting criteria for existing monitoring sites (Table 2) and for the proposed monitoring locations (Table 3). For all existing and proposed sites, it is implied that the practical considerations of power, accessibility, and security are all satisfied.

4.1 Existing Sites

A detailed description of each existing LBNL ambient air monitoring location is given below. Table 2 includes a checklist of siting criteria for the existing stations.

ENV-13A

Station ENV-13A is located at the western edge of the LBNL property that borders the UC-Berkeley campus and residential neighborhoods of Berkeley. ENV-13A sampling station was sited to measure tritium from any source at LBNL that may be transported toward the most densely populated area surrounding the Lab. This site has been strategically placed to increase the likelihood of detecting an unusual release of tritium. Surrounding trees and buildings have only a minimal influence on this monitor.

ENV-13C

Station ENV-13C is an existing monitor located off site on the southern side of Strawberry Canyon near Panoramic Way at approximately the same elevation as the NTLF. While not truly a background site by definition, this site is an offsite monitoring location where impacts from LBNL have shown to be non-detectable or negligible. This site is representative of offsite tritium concentrations in the residential, recreational, and ecological study area that borders the southern edge of the LBNL property.

Table 2. Checklist of siting criteria for the existing LBNL ambient air monitors[a].

Monitoring Site	Direction From NTLF	Located Within Limits of Detection[b] (30 Ci)[c]	Power Accessibility Security	Nearby Onsite Receptor	Nearby Offsite Receptor	Detect Other Sources[d]	Dose > 1 mrem/y
ENV-13A	W, WSW	No	✓	✓	✓	✓	No
ENV-13C	SSE	No	✓	No	✓	✓	No
ENV-13D	NW	No	✓	No	✓	No	No
ENV-69	ENE	✓	✓	✓	No	No	No
ENV-75EG	WNW, NW	✓	✓	No	No	No	No
ENV-85	E	✓	✓	✓	No	✓	No
ENV-LHS	NW, NNW	✓	✓	No	✓	No	No

[a] All stations in the existing network except ENV-75EG satisfy criteria in DOE's Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE, 1991). ENV-75EG was sited in response to concerns from the community.

[b] Defined as 2 to 5 pCi/m^3.

[c] Assuming an annual averaged release of 30 Ci HTO from the NTLF.

[d] Monitors sited to detect emissions from any LBNL source other than NTLF emissions. However, the additional sources account for less than 0.2% of the total emissions.

Table 3. Checklist of siting criteria for additional ambient air monitors[a].

Monitoring Site	Direction From NTLF	Located Within Limits of Detection[b] (30 Ci)[c]	Power Accessibility Security	Nearby Onsite Receptor	Nearby Offsite Receptor	Detect Other Sources[d]	Dose > 1 mrem/y
ENV-31	SE	✓	✓	✓	No	✓	No
ENV-44	SW, WSW	No	✓	✓	No	No	No
ENV-77	S	✓	✓	✓	No	No	No
ENV-78	SSW	✓	✓	✓	No	No	No
ENV-AR[d]	SE	No	✓	No	✓	No	No
ENV-MSRI	N	✓	✓	No	✓	No	No
ENV-SSL	NNE, NE	✓	✓	No	✓	No	No
ENV-UCBG[d]	ESE	No	✓	No	✓	✓	No

[a] All additional proposed stations were sited for reasons above and beyond the criteria given in DOE's Regulatory (DOE, 1991). Stations ENV-UCBG and ENV-AR have been selected in response to a supplemental monitoring request from EPA to provide sampling data in the HRS target ring distance category of 0.5 to 1 miles and the HRS target ring distance category of 1 to 2 miles, respectively.

[b] Defined as 2 to 5 pCi/m^3.

[c] Assuming an annual averaged release of 30 Ci HTO from the NTLF.

[d] Monitors sited to detect emissions from any LBNL source other than NTLF emissions. However, the additional sources account for less than 0.2% of the total emissions.

Like Station ENV-13A, this site has been strategically placed to increase the likelihood of detecting an unusual release of tritium. Historical results indicate that tritium concentrations are seldom detected at this site.

Although trees have an unavoidable influence in the region surrounding this sampler, this station has direct line of sight vision with the Building 75 complex.

ENV-13D

The ENV-13D monitoring station is representative of tritium concentrations at the northern edge of the LBNL property that borders a residential neighborhood of Berkeley. ENV-13D is situated northwest of the NTLF in line with the ENV-LHS site. This site is approximately five times further from the source than the ENV-LHS site.

This site has been strategically placed in one of the two predominant downwind directions from the NTLF, specifically the direction most commonly occurring during nighttime periods and storm events. ENV-13D is one of three stations in this direction from the NTLF, providing data on the rate of decrease in tritium levels in the second most frequent direction that the wind blows. This site has a minimal influence from trees and buildings.

ENV-69

The ENV-69 monitoring station has been placed to measure tritium concentrations at the northeastern edge of the LBNL property in the immediate vicinity of the NTLF facility. North of this station is an extensive region of undeveloped University of California wildland and ecological study area land.

This site has been placed in the most predominant downwind direction from the NTLF, specifically the direction that the wind most frequently blows during daytime periods. This station is the nearest sampling site to the source in this direction.

This station is located on the roof of a long, low building that is located in a naturally-occurring bowl. This combination minimizes the normal disruptions to airflow patterns caused by buildings. From a practical aspect, this is the best option for siting a station in this section of the LBNL property.

ENV-75EG

The purpose of Station ENV-75EG is to measure tritium concentrations in the vicinity of the Building 75 hillside stack within the eucalyptus grove. It is the nearest station to the stack.

Historical analyses of meteorological conditions and tritium dose assessments show that this site is in one of the two predominant downwind directions from the NTLF, specifically the direction most commonly occurring during nighttime periods and storm events. This is the first of three stations in this direction from the NTLF, providing an indication of how quickly tritium levels decrease with distance.

This station is heavily influenced by the surrounding grove of eucalyptus trees and would not adhere to most common criteria for siting ambient stations.

ENV-85

This site is located east of the NTLF near Building 85. This site is representative of tritium concentrations at the eastern edge of the LBNL property. Beyond this station is an extensive region of undeveloped University of California wildland and ecological study area land.

Historical analyses of meteorological conditions and tritium dose assessments show that this site is strategically placed in one of the two predominant downwind directions from the NTLF, specifically the most predominant direction and the direction that occurs mostly during daytime periods. Combining the results from this station with those from ENV-69 provides valuable data on the rate of decrease in tritium levels in this direction.

This station is also sited to include minor contributions from activities at the Hazardous Waste Handling Facility.

The influence of the terrain on flow patterns at the station is greater than any influence from trees or buildings. The chosen site minimizes the influence of all three factors in this area.

ENV-LHS

The ENV-LHS monitor is located at the Lawrence Hall of Science, on property owned by the University of California. Past annual NESHAPs compliance assessments have shown this site as the location of the maximally exposed individual (MEI). Although there is an influence from the nearby eucalyptus grove and the LHS building, these influences are offset by the need to collect data at a location representative of the MEI.

This site has been placed in the most commonly occurring direction for winds during nighttime hours and during storm events. This site, used in conjunction with Stations ENV-75EG and ENV-13D, provides information on the rate of decrease of tritium concentrations in the northwest wind sector.

4.2 Proposed Sites

A detailed analysis of projected tritium concentrations has been performed using the CALPUFF modeling system to identify locations that would best satisfy the practical considerations of sampling at a distance where detectable levels of tritium are predicted in directions from the NTLF where winds are less frequently expected to blow.

ENV-31

ENV-31 will be located in the southeast wind direction from the NTLF. This site will provide monitoring coverage for a wind sector that is currently without a sampling site. The absence of trees and buildings enhance the quality of this sampling location.

ENV-44

Station ENV-44 is located at the onsite 20-meter weather tower. This site would provide monitoring coverage for a sector that is currently without a sampling site. This monitor has been proposed for the detection of tritium should the winds blow in this infrequent wind sector during the time of a release. This proposed site is the nearest feasible to the NTLF in this wind sector.

ENV-77

Station ENV-77 will allow for the collection of monitoring data in the southern wind direction, which was previously unmonitored. This monitor will detect tritium should the winds blow in this infrequent wind sector during the time of a release. This monitor will be placed near Building 77, directly downhill from the Building 75 rooftop stack in the southern direction.

ENV-78

Station ENV-78 will allow for the collection of monitoring data in a wind sector that previously was unmonitored. This monitor will detect tritium should the winds blow in this infrequent wind sector during the time of a release. This monitor will be placed on the roof of Building 78, clearly visible from the Building 75 rooftop stack.

ENV-AR

This proposed station would be located at the East Bay Municipal Utility District's Amito Reservoir. The reason for selecting this site was to meet the needs of a supplemental monitoring request from EPA by providing sampling data in the HRS target ring distance category of 1 to 2 miles. The site experiences similar meteorological conditions in terms of temperatures, humidity, winds, and precipitation as LBNL. It also has a similar elevation as the NTLF. This site is expected to be representative of background tritium concentrations for the region.

ENV-MSRI

The ENV-MSRI is situated about halfway between ENV-LHS and ENV-SSL on the grounds of the University of California. The ENV-MSRI monitor will be located near the Mathematical Sciences Research Institute building. This site will provide monitoring coverage for a wind sector that is currently without a sampling site. This site is the nearest feasible location to the NTLF in this wind sector because of the presence of essential support services.

The MSRI building will have some influence on airflow near the sampler. However, building impact will be minimized because the building is not between the station and the NTLF. In addition, the inlet probe will be located as far away from the building as is feasible. Although there are no trees immediately adjacent to the sampler, the surrounding hillside has scattered clusters of trees.

ENV-SSL

The ENV-SSL monitor will be located at the satellite dish pad of the University of California's Silver Space Science Laboratory. This site will provide monitoring coverage for a wind sector that is currently without a sampling site. Although there are trees on the surrounding hillsides, the exposure of the pad is good for sampling. This site is the nearest feasible location to the NTLF for sampling in this wind sector because of the presence of essential support services.

ENV-UCBG

Station ENV-UCBG has been proposed in response to a request made by EPA to provide supplemental monitoring data in the HRS target ring distance category of 0.5 to 1 miles. This monitor will be located at the University of California Botanical Gardens.

This site has been strategically proposed in the most predominant downwind directions from the NTLF. The wind most frequently blows in this direction during daytime periods. Combining the results from this station with those from ENV-69 and ENV-85

provides additional valuable data on rates of decrease in tritium levels in this direction. The chosen site has excellent exposure to any winds coming from the direction of the NTLF.

4.3 Representation of 16 Standard Wind Sectors

The existing and proposed monitoring stations are included on an LBNL site map (Figure 6), which includes the 16 compass sectors centered on the NTLF. Observed wind patterns at the LBNL site indicate that the wind blows very rarely in some directions (e.g., from the N, NNE, NE and ENE wind sectors). The existing sampling stations are located in 7 of the 16 standard wind sectors. The proposed monitoring stations have been sited to cover the remaining wind sectors. Ten of the 16 sectors contain at least one monitoring station, while 4 stations (ENV-13A, ENV-LHS, ENV-SSL, and ENV44) border the remaining 6 sectors. In a practical sense, all wind directions are represented and the placement of stations is such that a higher than average release from the NTLF is likely to be detected under all meteorological conditions.

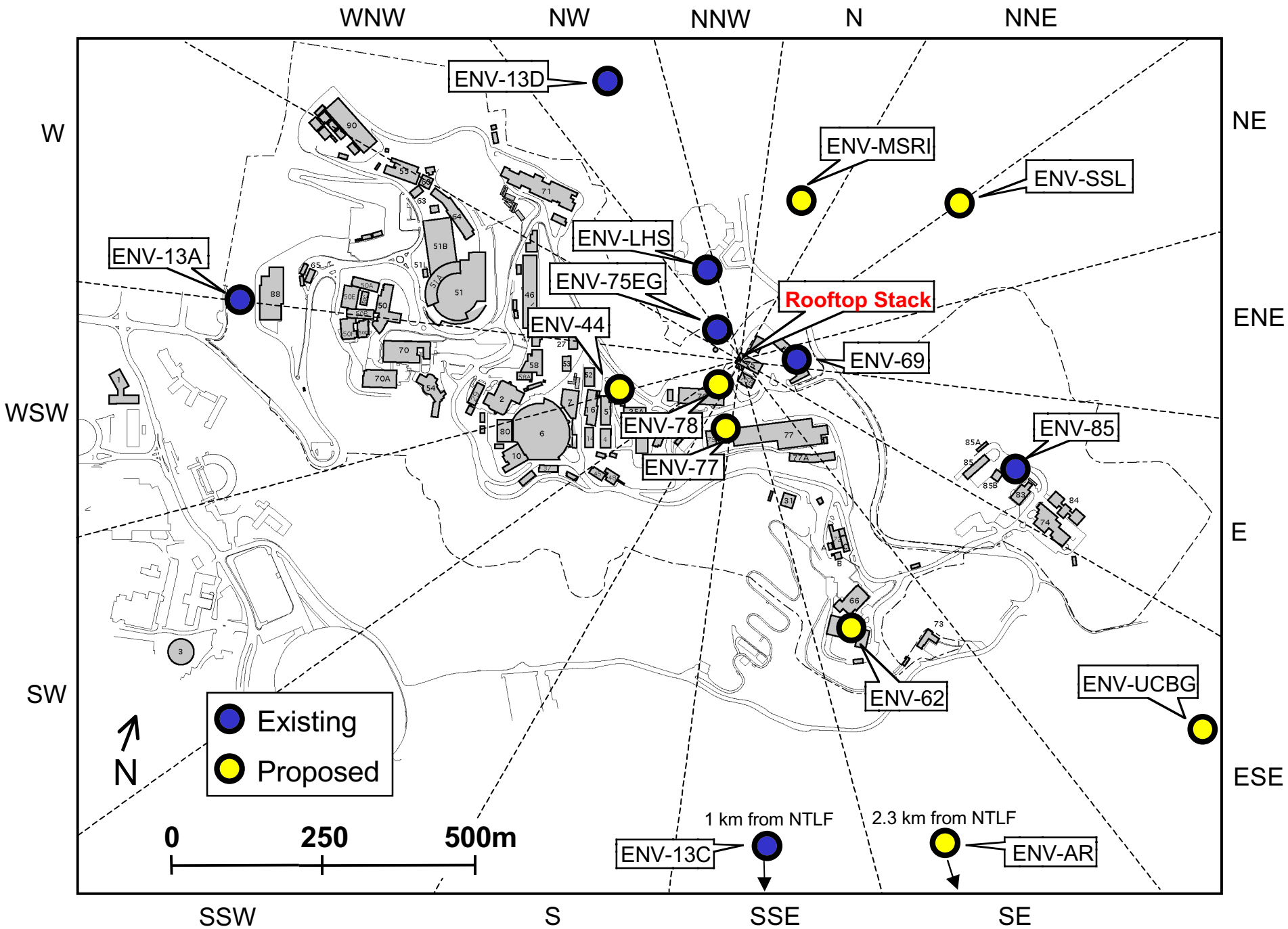

Figure 6. Existing and proposed monitoring locations with respect to the 16 standard wind sectors.

5.0 REFERENCE CONCENTRATIONS AND DOSES FOR HTO IN AIR

This section discusses how the air concentrations of HTO estimated in Figures 2 through 5 can be put into perspective with NESHAP dose limit of 10 mrem/yr and the DOE guidance for siting air monitors of 1 mrem/yr. Reference air concentrations and associated effective whole body doses based on exposure to HTO from inhalation and skin absorption are given in Tables 4a and 4b. Food ingestion of HTO is not considered, as this exposure route would be relevant only for locations where food crops are produced for local consumption.

The dose estimates in Tables 4a and 4b assume two conditions: (1) that the radiological decay of tritium incorporated into cellular material is no more effective than x-rays (quality factor equal to 1), and (2) an elevated quality factor ranging from 1.0 to 5.0, with a mode of 2.0 (Thomas and Hoffman, 2000; Straume, 2000; Straume, 1998; Straume, 1993).

Reference air concentrations and associated whole body doses for a male onsite worker exposed to various air concentrations of HTO are given in Table 4a. It is assumed that the male worker will be exposed for 9 hours per day, 5 days per week, for 52 weeks, minus vacation, holidays, and sick-leave for a total of 2043 hours per year. An elevated breathing rate ranging from 24 to 43 m^3/d is used for this assessment (EPA, 1997).

Reference air concentrations and associated whole body doses for a male offsite resident are presented in Table 4b. It is assumed that the offsite resident will be exposed for 24 hours per day, 7 days per week, for 50 weeks for a total of 8,400 hours. An average daily breathing rate ranging from 13 to 23 m^3/d has been assumed for the offsite resident (EPA, 1997). The largest air concentration presented in Table 4b (2,300 pCi/m^3) is equivalent to an upper bound whole body dose of 10 mrem in a year, assuming the quality factor adjustment.

The maximum annual dose estimated for all plausible onsite and offsite air concentrations resulting from a release of 30 Ci/y HTO is less than 0.09 mrem/y (for an offsite air

concentration of 20 pCi/m^3). This dose would add less than one tenth of 1% to natural background radiation, which is approximately 100 mrem per year, excluding the dose from indoor radon (NCRP, 1987). It is also less than 1% of the NESHAPs limit of 10 mrem per year. The annual doses for all air concentrations seen in Figures 2 through 5 are far below quantities considered to be of concern by State and Federal agencies responsible for the protection of public health and are far below the NCRP negligible dose level of 1 mrem per year (NCRP, 1993).

The health risk associated with prolonged exposure at these levels would be so low as to be indistinguishable from zero. Tables 4a and 4b clearly demonstrate the small levels of exposure and dose that would be associated with present day releases of tritium from the NTLF. Present day environmental standards for tritium would not be exceeded even if the NTLF were to release quantities consistent with its operations of more than 10 years in the past.

Table 4a. Annual whole body doses[a] for a male onsite worker[b] exposed to various reference air concentrations of HTO.

Reference Air Concentration (pCi/m^3)[c]	**Dose (mrem/yr[c]) without quality factor adj.[d]** 95% uncertainty range lower	central	upper	**Dose (mrem/yr[c]) with quality factor adj.[e]** 95% uncertainty range lower	central	upper	Notes
6200	0.81	1.6	3.0	1.5	4.0	10	Air concentration equivalent to an upper bound whole body dose of 10 mrem in a year via the inhalation and skin absorption pathways.
620	0.081	0.16	0.30	0.15	0.40	1.0	Air concentration equivalent to an upper bound whole body dose of 1 mrem in a year.
50	0.0065	0.013	0.025	0.012	0.032	0.081	EPA screening value for Hazard Ranking Scoring of sites for potential designation on the National Priorities List (this value is not applicable to operating permitted facilities).
20	0.0026	0.0050	0.0098	0.0048	0.013	0.032	The highest annual average isoconcentration line predicted either by mathematical models or wind tunnel studies for an annual release of 30 Ci.
10	0.0013	0.0025	0.0049	0.0024	0.0064	0.016	The highest offsite annual average isoconcentration line predicted either by mathematical models or wind tunnel studies for an annual release of 30 Ci.
5	0.00065	0.0013	0.0025	0.0012	0.0032	0.0081	The minimum level of analytical detection for tritium (2 to 5 pCi/m^3).
2	0.00026	0.00050	0.00098	0.00048	0.0013	0.0032	The minimum level of analytical detection for tritium (2 to 5 pCi/m^3).
1	0.00013	0.00025	0.00049	0.00024	0.00064	0.0016	2 to 5 times below limits of analytical detection for silica gel ambient air monitors.
0.1	0.000013	0.000025	0.000049	0.000024	0.000064	0.00016	20 to 50 times below limits of analytical detection for silica gel ambient air monitors.

[a] All doses based on exposure due to the inhalation and skin absorption pathways.

[b] It is assumed that the onsite worker will potentially be exposed for 9 hours per day, 5 days per week, for 52 weeks (2,340 hours/year), minus vacation, holidays and sick-leave (approximately 33 days/year). Therefore, it is assumed that the onsite individual is exposed 2043 hours per year. An elevated breathing rate ranging from 24 to 43 m^3/d has been assumed for the worker (EPA, 1997).

[c] To convert mrem to Sv, multiply by 10^{-5}. To convert pCi/m^3 to Bq/m^3, multiply by 0.037.

[d] Quality factor for tritium is assumed to 1.0.

[e] Quality factor for tritium is assumed to be a triangular distribution ranging from 1.0 to 5.0, with a mode of 2.0 (Thomas and Hoffman, 2000).

Table 4b. Annual whole body doses[a] for a male offsite resident[b] exposed to various reference air concentrations of HTO.

Reference Air Concentration (pCi/m^3)[c]	**Dose (mrem/yr[c]) without quality factor adj.[d]** 95% uncertainty range lower	central	upper	**Dose (mrem/yr[c]) with quality factor adj.[e]** 95% uncertainty range lower	central	upper	Notes
2300	0.74	1.5	3.1	1.5	3.8	10	Air concentration equivalent to an upper bound whole body dose of 10 mrem in a year via the inhalation and skin absorption pathways.
230	0.074	0.15	0.31	0.15	0.38	1.0	Air concentration equivalent to an upper bound whole body dose of 1 mrem in a year.
50	0.016	0.033	0.067	0.032	0.084	0.22	EPA screening value for Hazard Ranking Scoring of sites for potential designation on the National Priorities List (this value is not applicable to operating permitted facilities).
20	0.0064	0.013	0.027	0.013	0.033	0.087	The highest annual average isoconcentration line predicted either by mathematical models or wind tunnel studies for an annual release of 30 Ci.
10	0.0032	0.0065	0.013	0.0064	0.017	0.043	The highest offsite annual average isoconcentration line predicted either by mathematical models or wind tunnel studies for an annual release of 30 Ci.
5	0.0016	0.0033	0.0067	0.0032	0.0084	0.022	The minimum level of analytical detection for tritium (2 to 5 pCi/m^3).
2	0.00064	0.0013	0.0027	0.0013	0.0033	0.0087	The minimum level of analytical detection for tritium (2 to 5 pCi/m^3).
1	0.00032	0.00065	0.0013	0.00064	0.0017	0.0043	2 to 5 times below limits of analytical detection for tritium.
0.1	0.000032	0.000065	0.00013	0.000064	0.00017	0.00043	20 to 50 times below limits of analytical detection for tritium.

[a] All doses based on exposure due to the inhalation and skin absorption pathways.

[b] It is assumed that the offsite resident will potentially be exposed for 24 hours per day, 7 days per week, for 50 weeks. A breathing rate ranging from 13 to 23 m^3/d has been assumed for the resident (EPA, 1997).

[c] To convert mrem to Sv, multiply by 10^{-5}. To convert pCi/m^3 to Bq/m^3, multiply by 0.037.

[d] Quality factor for tritium is assumed to 1.0.

[e] Quality factor for tritium is assumed to be a triangular distribution ranging from 1.0 to 5.0, with a mode of 2.0 (Thomas and Hoffman, 2000).

6.0 CONCLUSIONS

The detailed technical analysis discussed in this report defines a set of criteria used to review the current network of 7 ambient air monitoring stations and to justify the placement of 8 additional monitors.

The current ambient air monitoring network of 7 monitoring stations meet all criteria for monitoring tritium at sites operated for DOE. Although there are no regulatory or dose-based requirements for expanding the monitoring network at LBNL, the expansion to 15 stations is proposed to be responsive to recommendations made by IFEU to ensure that elevated short-term releases of tritium from the NTLF will be detected by air monitors placed in sectors of low wind frequency (Franke and Greenhouse, 2000; Franke and Greenhouse; 2001).

These criteria include consideration of the location of nearby population centers (both onsite and offsite), the placement of monitors with respect to the 16 standard wind sectors, and whether the site is located at a distance that would be associated with detectable concentrations of HTO in air. Other criteria include whether the site has access to dedicated electrical service, is easily accessible, and is reasonably secure.

Other sites were considered for the placement of monitoring stations and have been rejected due to the absence of available power sources, steep terrain, locations too far outside minimum level of detection, or the presence of safety hazards for those responsible for maintaining the equipment.

The annual averaged concentrations of HTO estimated using CALPUFF are comparable in magnitude to estimates produced from the UC Davis wind tunnel study and CAP88-PC computer code, although dispersion patterns differ. According to our estimates, the maximum onsite dose to a worker exposed during an average work year would be less than 0.032 mrem/y. The maximum dose to an offsite resident exposed 24 hours per day would be less than 0.087 mrem/y. All doses received as a result of operations at the

NTLF would be far below the applicable NESHAPs standard of 10 mrem/y. In addition, doses less than 1 mrem/y are considered negligible by the NCRP.

The recommended expansion of the ambient air network to 15 stations will have 7 stations located within 300 meters of the planned Building 75 rooftop stack. In addition, atmospheric modeling with CALPUFF indicates that 9 stations are located within the minimum detectable range for an annual release of 30 Ci. The maximum onsite and offsite air concentrations indicate exposures that are very small fractions of regulatory standards and are clearly below the NCRP negligible dose level of 1 mrem/y.

An additional benefit of the proposed expanded network is that the CALPUFF model can be calibrated to onsite and offsite monitoring results for the sectors and distances not directly covered by monitoring stations. These calibrated estimates can be used to increase the confidence in predicted concentrations of HTO in downwind directions and distances not explicitly represented by an ambient air station, or where concentrations are below limits of detection.

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UNITS CONVERSION

This report refers to radiation quantities in the old (U.S.) units. The factors for converting these values into the new (SI) units are provided in Table 5.

Table 5. Units Conversion Table

To convert	**To**	**Multiply by**
Ci	Bq	3.7×10^{10}
pCi	Bq	0.037
mrem	Sv	1×10^{-5}